U. S. FOREST SERVICE

RESEARCH NOTE NC-92

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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Effect of Cutting Angle and Depth of Cut on the Occurrence of Chipped Grain on Sycamore

ABSTRACT.— Sycamore specimens were planed with various combinations of depths of cut and rake angles. Depths of cut up to 1/16 inch had no significant effect on the occurrence of chipped grain in sycamore but rake angle did.

OXFORD: 823.1:823.8:176.1 *Platanus occidentalis*

Guidelines for depth of cut and rake angle have been established for planing hardwood lumber. It has generally been accepted in practice, but not shown for all combinations of rake angles and depths of cut, that the thinner the depth of cut the higher the quality of the resulting surface. Davis, [1] when planing hardwood with a depth of cut as shallow as 1/32 inch and a rake angle of 30 degrees, showed that the greatest increase of defect-free specimens occurred when depth of cut was reduced from 1/16 inch to 1/32 inch. However, an interaction between smaller rake angles and shallow depths of cut, and the effect of various combinations of rake angles and depths of cut upon the occurrence of chipped grain have not been established. So we undertook a study to determine how shallow depths of cut (1/16 to 1/64 inch) in various combinations with four rake angles (25, 20, 15, and 10 degrees) would affect the occurrence of chipped grain within rough and finish milled sycamore specimens.

[1] *Davis, E. M. Machining and related characteristics of United States hardwoods. U. S. Dep. Agr. Tech. Bull. 1267, 68 p., illus. 1962.*

The results indicate that when cutting with rake angles less than 30 degrees and thin depths of cut, rake angle does not interact with depth of cut.

METHOD OF STUDY

Nine cutting combinations (table 1) were replicated nine times and analyzed as a split-plot design where cutting angle was the major treatment and the rough and finish milling depth-of-cut combinations were the minor treatments. No combination of cutting depths exceeded 3/32 inch, the amount commonly finish planed to produce a satisfactory surface.

The specimens (1- by 4- by 25-inches) were cut from sycamore lumber kiln-dried and maintained at an average moisture content of 7 percent. They were planed on one side to provide

Table 1.—Depth-of-cut combinations used in study

(In 64ths of an inch)

Combination	Planing operations		
	Rough	First finish	Second finish
1	4	2	-
2	4	1	1
3	3	3	-
4	3	2	1
5	3	1	1
6	2	2	2
7	2	2	1
8	2	1	1
9	1	1	1

Note: Combined rough and finish cuts tested do not exceed 3/32 inch.

a flat surface and nearly uniform thickness so the rough milling cut would be relatively accurate.

After each pass through the molding machine against any predominent slope of grain at the prescribed cutting depth and rake angle, and at a rate of 16 knife marks per inch, the number of 1-inch square sections where chipped grain occurred was recorded as a percent of the total surface machined.

RESULTS AND DISCUSSION

Results show that:

1. Depth of cut up to 1/16 inch does not significantly influence the occurrence of chipped grain using the rake angles studied.

2. Rake angle does significantly influence the occurrence of chipped grain at depths of cut up to 1/16 inch, and the rake angle does not interact with depths of cut up to 1/16 inch.

Twenty percent of the specimens planed with a cutting depth of 1/32 inch were defect-free regardless of rake angle. In Davis' study the corresponding figuure was 22 percent. Hence, evaluating machine combinations of depth of cut and rake angle quantitatively by subdividing specimens and repeating the treatment is a refinement for measuring the occurrence of chipped grain compared with previous surface quality evaluation methods.

Chipped grain occurred most frequently with a 25-degree-rake-angle knives – the knives commonly furnished with finish planers to plane both hardwoods and softwoods (fig. 1). Hardwoods should generally be planed with knives of a rake angle of 20 degrees or less to reduce chipped grain. Although smaller rake angles produce less chipped grain, they usually require more power and the edges more frequent sharpening. Hence, to determine optimum rake angles, other factors beyond the scope of this study need to be considered.

Since depth of cut up to 1/16 inch (fig. 2) does not influence the occurrence of chipped grain in sycamore and results from other species may be similar, mill managers and machine operators should consider making more passes through planing machinery at shallower depths of cut and closer sawmill adjustment to reduce initial depths of cut and hence overall waste.

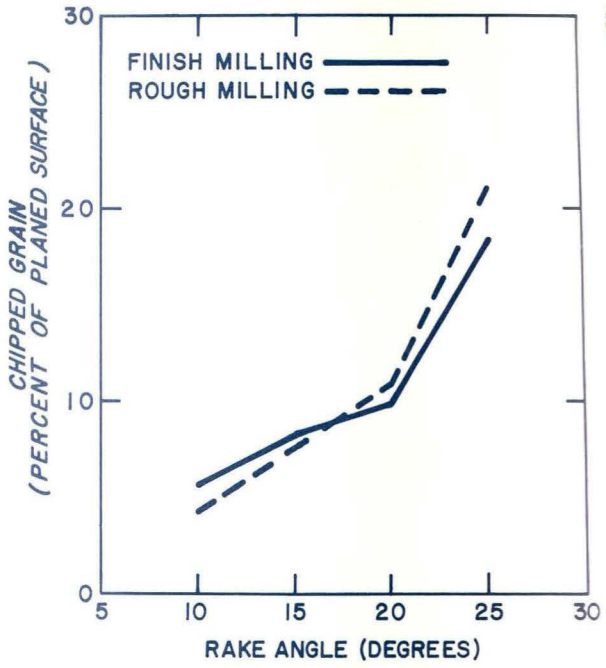

Figure 1.—The relation of chipped grain to rake angle by rough and finish planing.

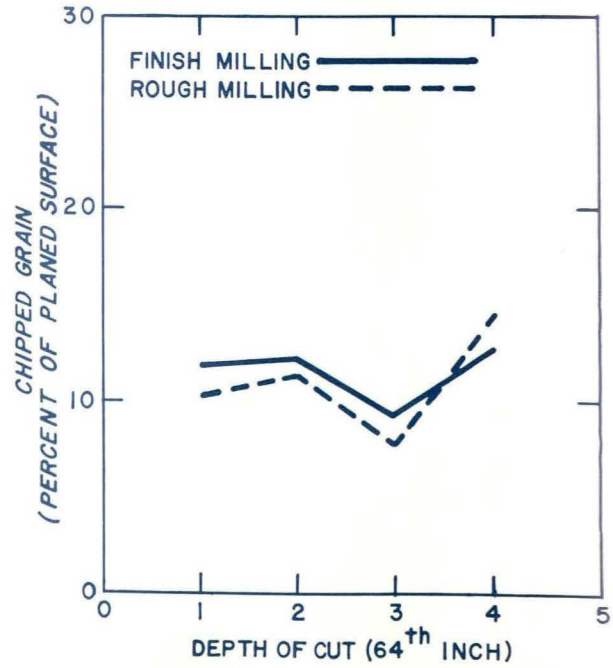

Figure 2.—The relation of chipped grain to a depth of cut, by rough and finish planing.

Cuts deeper than 1/16 inch were not included in the formal study because they exceed the amount commonly prescribed to produce a satisfactory finish-planed surface. Supplemental data however, show chipped grain increased as depth of cut increased beyond 1/16 inch (fig. 3). The greatest apparent increase was in the severity of the defect below the surface (fig. 4). Such a defect would cause a part to be rejected or would require subsequent processing. Consequently, the severity of the defect and not frequency of occurrence may limit the acceptability of a part. This suggests that the depth of the defect should also be measured in future studies to evaluate surface quality.

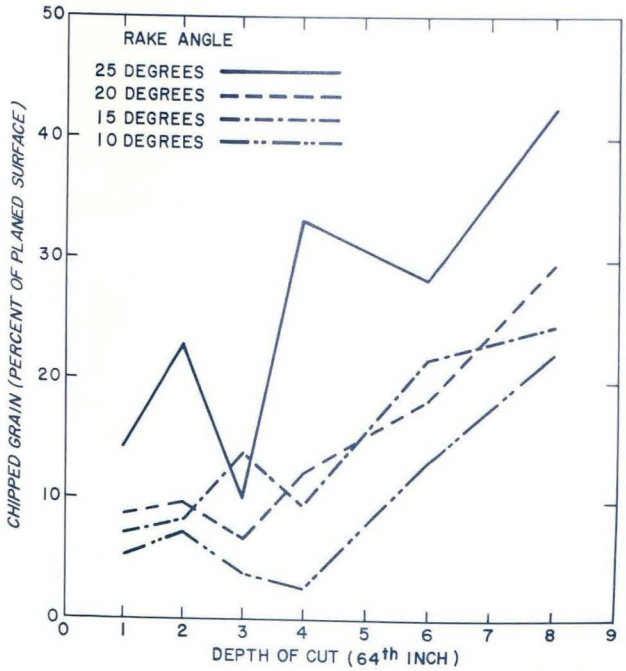

Figure 3.—The relation of chipped grain to depth of cut by rake angle (finish planing only).

When planing with the grain, many combinations of cutting angles and depths of cut will produce a satisfactory surface. When planing against the grain, however, chipped grain is a common defect that requires further processing. We do not presume from these results that all machining defects can be prevented, but chipped grain can be reduced and raw material can be saved by determining the best machining methods.

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Figure 4.—The occurrence of severe chipped grain when planing with a 25-degree rake angle and a depth of cut of 1/8 inch. This material would be rejected or would require substantial subsequent processing.

Because of the allowable variation of thickness within hardwood lumber, [2] initial depths of cut are variable. The depth of the planing cuts may range from almost zero to the machine setting (often 1/8 inch or more) when face jointing. Since the first pass on the thickness planer is often set to remove a nominal 1/16 inch from 4/4-inch lumber (plane to a thicknees of 15/16 inch), the actual depth of cut can range from almost zero to 3/16 inch due to the variability in thickness allowed in rough hardwood lumber. Large initial depths of cut in rough

[2] *National Hardwood Lumber Association. Rules for the measurement and inspection of hardwood and cypress lumber. 116 p., illus. 1967.*

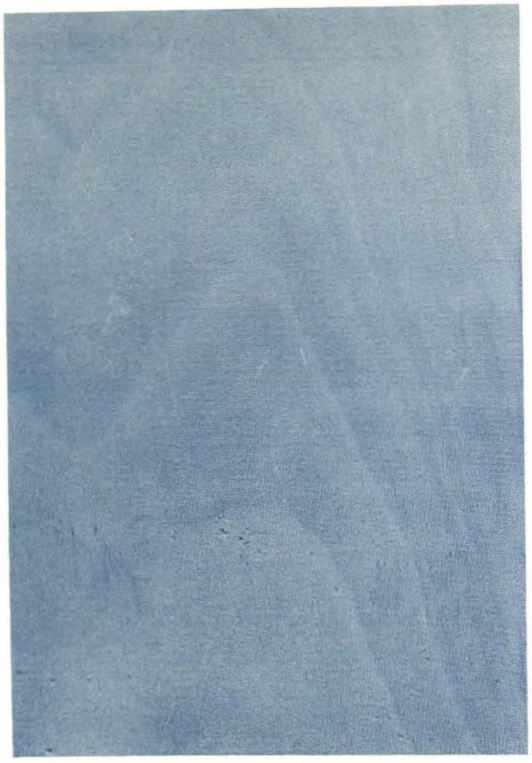

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Figure 5.—The occurrence of chipped grain when planing with a 25-degree rake angle and a depth of cut of 1/16 inch. The severity (distance of the defect extending below the surface) of chipped grain becomes negligible at more shallow depths of cut.

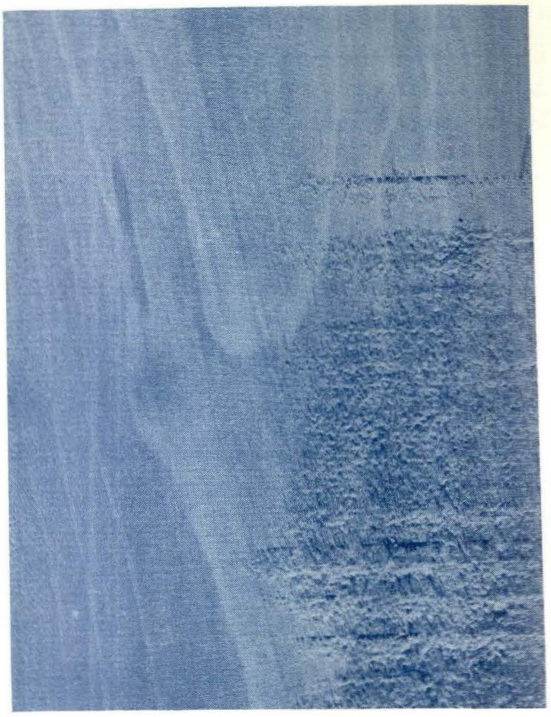

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Figure 6.—Surface produced by rough milling at a depth of cut of 1/64th inch. Although saw marks remain, any chipped grain which occurred was hardly discernible; hence, subsequent processing would be minimal. The sanding process could be incorporated to remove final traces of saw marks and thus conserve raw material.

milling cause many defects that must be removed by finish planing. Further, many wood machining defects remaining after finish planing result from deep cuts when rough planing. Chipped grain can be reduced if the initial depths of cut are reduced (fig. 4, 5, 6).

Except for ripping and crosscutting the lumber, dimension part processing consists primarily of reducing thickness and removing surface milling defects from previous processing. Thus, rough planing removes rough sawing marks, finish planing removes rough planing defects, and sanding removes finish planing defects. The development of improved sawing equipment and techniques to produce thinner and more precisely dimensioned lumber should be encouraged to take full advantage of the benefits of shallow cutting. It follows that correct wood-seasoning practices must also be carried out to minimize deviations from flatness that could also affect depth of cut. Thus, initial rough milling depths of cut could be reduced, chipped grain would be reduced, and subsequent processing could be reduced.

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